Ecological Interactions Associated with Cultured and Restored Bivalve Populations in Chesapeake Bay

Mark W. Luckenbach
Virginia Institute of Marine Science

During the 20th century populations of the eastern oyster, *Crassostrea virginica*, declined dramatically in Chesapeake Bay. A growing body of evidence indicates that oysters were a keystone species in this system and that their demise has resulted in large-scale changes in the ecosystem. The loss of filtration by oysters and the biogenic habitat that they create are suspected of increasing eutrophication, altering food webs and resulting in the decline of numerous reef-dependent fishes. Two recent activities in the Chesapeake Bay may offer the potential to reverse this trend and restore some of the role of shellfish in controlling phytoplankton dynamics and in providing habitat for other species. Active restoration efforts are underway to rebuild reefs and their associated populations, and aquaculture of both hard clams (*Mercenaria mercenaria*) and oysters is expanding rapidly. A number of studies are currently underway that are attempting to elucidate ecological interactions of these managed shellfish habitats within the surrounding landscape. Separate studies investigating the assemblages of organisms associated with experimental reef restoration projects and with oyster aquaculture floats have identified comparable assemblages associated with each. Coupled with estimates of filtration capabilities, these findings suggest that shellfish habitats could be managed to restore lost ecological functions in the bay.

Environmental Response to the Intensive Cultivation of Fish and Shellfish in the Pacific Northwest

Kenn Brooks
Aquatic Environmental Science Laboratory

Supplying the fish and shellfish necessary to feed the earth's burgeoning human population has placed an unsustainable strain on fish and shellfish resources all around the globe. Modern terrestrial agricultural has developed to the point where we raise the meat, vegetables and grains on a fraction of the available uplands. Despite over 50 years of hard work by Conservation Districts and the Natural Resources Conservation Service to reduce erosion, soil losses from upland agriculture in Washington State still averaged four to eleven tons of topsoil per year from each acre of cultivated land. These fertile soils are washed into our streams, rivers, lakes and estuaries. It takes decades to centuries for this material to work its way downstream to the ocean. This is one of the costs of a human population that is nearing six billion people. Similarly, the intensive cultivation of fish and shellfish also creates changes in local marine environments. The focus of this talk is on the environmental effects associated with shellfish culture. However, because much of my research focuses on the greater effects associated with fish culture, I will rely on that experience as well. Aquaculture effects are generally of four kinds. Structural effects create new types of habitat and generally increase the abundance and diversity of life around aquaculture facilities. Water column effects are created by the uptake of detritus, phytoplankton and oxygen—and the release of nutrients from large growing biomasses of fish and shellfish. Adverse effects on the water column have rarely been documented in association with aquaculture and they have not been observed in the Pacific Northwest. Benthic effects are created by the deposition of biological debris, including pseudofeces, feces and fouling organisms from raft culture of shellfish and feces from netpen culture of finfish. These physicochemical changes frequently lead to changes in benthic communities. In well flushed environments these biodeposits frequently lead to significant increases in both the diversity and abundance of benthic communities. In slowly circulating bodies of water, the rate of biodeposit accumulation can exceed the assimilative capacity of the sediments leading to excess biological oxygen demand, oxygen depletion, and the creation of excess sulfides. As organic loading increases, sediments may become dominated by what are called opportunistic organisms—generally annelids like *Capitella capitata*. In extreme cases sediments can become anaerobic, dapauperate and covered with white mats of Beggiatoa.

However, unlike terrestrial agriculture, these effects have repeatedly been demonstrated to be ephemeral lasting from a few weeks following harvest to at most a few years in association with fish culture. Current studies in British Columbia are revealing the relationship between benthic communities and sediment concentrations of organic carbon, oxygen and total sulfides. These studies are demonstrating that benthic community changes can be predicted by evaluating the concentration of total sediment sulfides and the oxidation-reduction potential. Preliminary results suggest that total sulfide levels less than 800 micromoles are associated with biological amplification; concentrations of 1000 to 2000 micromoles with changes in community structure and domination by opportunistic organisms; and that benthic communities become increasingly depauperate at concentrations above 3,000 micromoles. These studies will be complete in May of 2001. It is my experience that the environmental effects associated with aquaculture are far shorter lived and more easily managed than the environmental risks associated with upland agriculture. To assist in managing the risks associated with mussel culture, I have recently completed work on a technical document supporting an environmental impact statement for raft culture of mussels. This work describes various methods for assessing the environmental response to intensive mussel culture and indicates that Totten Inlet, in South Puget Sound is currently at about ten percent of its bivalve carrying capacity. Furthermore, this work indicates that intensive bivalve culture tends to smooth out nutrient flows and phytoplankton production over a longer period each year. The sustainability of marine life depends very much on a healthy environment and on aquaculture's ability to satisfy much of humankind's demand for fish and shellfish—thereby taking pressure off wild stocks. The real question confronting those who care about marine resources is not whether or not we embrace aquaculture in the Pacific Northwest or push it offshore into third world countries. The important question is how do we manage aquaculture so that it remains a beneficial tool in our efforts to sustain all marine resources throughout the world.

The Role of Oyster Aquaculture as Habitat in West Coast Estuaries: A Review

Brett R. Dumbauld
Washington State Department of Fish and Wildlife

A review of several field studies suggests that oyster aquaculture practices have an influential role in structuring the benthic macro-invertebrate community in west coast estuaries. Oysters act as “bio-engineers” changing the structure of the substrate and creating habitat for other organisms. Macro-invertebrate communities are typically more diverse in intertidal ground culture oyster habitat as compared to other estuarine habitats, in particular intertidal mud and burrowing thalassinid shrimp dominated habitats. Oysters add structure for macro-algal, mussel and barnacle attachment which in turn provide protection and/or food for juvenile Dungeness crab, shore crabs *Hemigrapsus*, tube building gammarid amphipods such as *Amphithoe* and *Corophium*, caprellid amphipods, tanaids, and some annelids such as the scaleworm *Harmothoe*. Two other bio-engineers, the ghost shrimp *Neotrypaea californiensis* and the mud shrimp *Upogebia pugettensis*, dominate large portions of the intertidal in some west coast estuaries and compete for space with oysters and eelgrass. These thalassinid shrimp create a soft, highly burrowed habitat suitable for other burrowing organisms like the amphipods *Eohaustorius* and *Eobrolgus*, the polychaete *Mediomastus*, and some commensal organisms like the clam *Cryptomya*, but support fewer large filter feeders, less habitat for larger mobile crabs, and much lower species diversity than oyster habitat. Some proposed work aims to compare the functional role of oyster dominated habitat versus that dominated by eelgrass and open sand/mud dominated by thalassinid shrimp for the estuarine fish community, but to date, little has been done to estimate the effects of oyster aquaculture and farming practices at the larger estuarine ecosystem scale.